

COMMITTEE ON WIRELESS TELEGRAPHY RESEARCH

REPORT

OF THE

COMMITTEE APPOINTED BY THE POSTMASTER
GENERAL (OF GREAT BRITAIN) TO CONSIDER
AND REPORT HOW FAR AND BY WHAT METH-
ODS THE STATE SHOULD MAKE PROVISION FOR

RESEARCH WORK IN THE SCIENCE OF
WIRELESS TELEGRAPHY



PRESENTED BY MR. BURTON

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COMMITTEE ON
WIRELESS TELEGRAPHY RESEARCH

REPORT

FOR THE YEAR 1917 BY THE COMMITTEE
ON WIRELESS TELEGRAPHY RESEARCH
OF THE NATIONAL ACADEMY OF SCIENCES
AND THE NATIONAL RESEARCH COUNCIL

RESEARCH WORK IN THE FIELD OF
WIRELESS TELEGRAPHY

CONSTITUTION OF THE COMMITTEE.

The Right Hon. Lord PARKER of Waddington (chairman).¹
Sir JOSEPH LARMOR, M. P., F. R. S.
Sir HENRY NORMAN, M. P.
Dr. R. T. GLAZEBROOK, C. B., F. R. S.
W. DUDELL, Esq., F. R. S.
R. WILKINS, Esq., C. B.
Rear-Admiral CHARLTON, C. B.
Commander J. K. IM THURN, R. N.
Sir A. F. KING, K. C. B.
W. SLINGO, Esq.
Commander F. LORING, R. N.
Major the Hon. C. H. C. GUEST, M. P.
Lieut. Col. J. S. FOWLER, D. S. O., R. E.
S. J. FARRER, Esq. (secretary).

TERMS OF REFERENCE.

To consider and report how far and by what methods the State should make provision for research work in the science of wireless telegraphy, and whether any organization which may be established should include problems connected with ordinary telegraphy and telephony.

¹ The original chairman was the Right Hon. C. E. Hobhouse, who retired when he became Postmaster General, and appointed Lord Parker of Waddington in his place.

CONSTITUTION OF THE UNITED STATES

Article I, Section 1, Clause 1

All legislative Powers herein granted shall be vested in a Congress of the United States, which shall consist of a Senate and House of Representatives.

Section 2, Clause 1

The House of Representatives shall be composed of Members chosen every second Year by the People of the several States, and the Electors in each State shall have the Qualifications requisite for Electors of the most numerous Branch of the State Legislature.

Section 3, Clause 1

The Senate of the United States shall be composed of two Senators from each State, chosen by the Legislature thereof, for six Years; and each Senator shall have the Qualifications requisite for Senators of the most numerous Branch of the State Legislature.

Section 4, Clause 1

The Times, Places and Manner of holding the Elections of Senators and Representatives, shall be prescribed in each State by the Legislature thereof; but the Congress may at any time by Law make or alter such Regulations, except as to the Places of Elections.

ARTICLE II

Section 1, Clause 1
The executive Power shall be vested in a President of the United States of America. He shall hold his Office for four Years, and, together with the Vice President, chosen for the same Term, shall be elected in the following Manner:—
Each State shall have one Vote, which shall be given by the Electors in that State, the Number of which Electors shall be equal to the whole Number of Senators and Representatives which that State may be entitled to in Congress, but which Electors in any State shall have the Qualifications requisite for Electors of the most numerous Branch of the State Legislature.

REPORT OF THE COMMITTEE ON WIRELESS TELEGRAPHY RESEARCH.

To the Right Hon. C. E. HOBHOUSE,
His Majesty's Postmaster General.

SIR: Under the terms of our appointment we were requested to consider and report how far and by what methods the State should make provision for research work in the science of wireless telegraphy, and whether any organization which may be established should include problems connected with ordinary telegraphy or telephony.

2. Immediately after our appointment we took measures to inquire (1) what work either by way of experiment or research in matters connected with wireless telegraphy was being already done by Government departments in this country, and (2) what work was being done on similar lines by State departments or institutions in the United States and in Germany.

3. As the result of our first inquiry, we ascertained the several facts stated in the four following paragraphs of this report.

4. Valuable work in the way both of experiment and of research has for some time past been and is now being done in the engineering department of the general post office. Such department, however, is sometimes hampered by insufficiency of funds, and the matters it investigates are unavoidably such as have an immediate bearing on service problems rather than on the principals which underlie wireless telegraphy on its scientific side.

5. Valuable work by way of experiment and research is also being done by the Admiralty, but this, as might be expected, is almost entirely restricted to matters having an immediate bearing on the adaptation of the methods of wireless telegraphy to meet service conditions.

6. Some work is also being done both by way of experiment and research by the war office, but again chiefly with a view to the practical requirements of the military authorities.

7. Those responsible for the departmental work to which we have referred are of opinion that further experiment and research in matters of general principle with which the departments can not under present conditions deal themselves is urgently needed. A detailed list of such matters has been laid before us, and will be found in the schedule herewith. It will be seen that some of these matters can only be studied in a laboratory, while for others the use of a fully equipped telegraphic or wireless station is necessary.

8. As the result of our second inquiry we ascertained that both in the United States and in Germany the State makes more liberal and extensive provision than is made by the State in this country for research and experimental work in wireless telegraphy.

9. In the United States this work is undertaken by three distinct departments, namely, the Navy, the Army Signal Service Corps, and the Bureau of Standards, but in order to secure economy and cooperation all these departments are, for purposes of laboratory research, brought under one roof in the buildings of the Bureau of Standards.

10. In Germany the work is carried out by the post office in the Kaiserliches Versuchsamts, a building containing 30,000 square feet of floor space. The work undertaken in this building is not confined to wireless telegraphy, but covers the whole range of electrical engineering as applied to telegraphy, whether ordinary or wireless, and telephony. It is under the direction of Dr. Strecker, assisted by a large and competent staff, the research work in wireless telegraphy being under the charge of Dr. Kiebitz and Dr. Breisig. Research work of importance in wireless telegraphy has also been conducted by Dr. Lindemann at the Reichsanstalt in Berlin, and by Dr. Reich in the Naval and Military Electric Laboratory in Gottingen.

11. It must be remembered that the scientific results of the research work undertaken by the State both in the United States and Germany are for the most part published, and this country benefits thereby.

12. A careful consideration of the above facts has led us to the following conclusions, namely:

(1) That it is desirable to establish some body or institution to initiate and control research in matters of general principle which can not conveniently be investigated in departmental laboratories, to coordinate as far as may be the work now undertaken by the post office, admiralty, and war office, respectively, in connection with experiment and research in wireless telegraphy, so as to prevent work undertaken by one department overlapping work undertaken by another, and thus secure economy, and to discuss any difficulties arising in practice.

(2) That the work now being done by the departments should be continued and extended, opportunities being also found for the departmental engineer to carry out such experiments and tests as may be approved by the body or institution to be established for the purposes above referred to, and may require high power and service conditions.

(3) That it is desirable to establish a research laboratory (as distinguished from the existing departmental laboratories and service stations), in which research work bearing on the practical needs of the services should be carried out under the guidance of the body or institution above referred to.

(4) That though the work to be undertaken by the new body or institution and in the new laboratory, the establishment of which we recommend, will principally concern wireless telegraphy, it is undesirable to exclude therefrom the problems of ordinary telegraphy and telephony.

13. In considering the lines on which the proposed new body or institution should be established, we have derived great assistance from the experience of the advisory committee for aeronautics established in 1909. We understand that this committee has worked smoothly and satisfactorily and has fulfilled the purposes for which it was created, those purposes being in all respects analogous to the purposes which we have in view. The research work of this committee is carried out in the National Physical Laboratory at Teddington, and we are of opinion that the new research laboratory for

wireless telegraphy should also be worked in connection with that institution.

14. After careful consideration we have formulated and recommend the adoption of the following scheme, in which the word "telegraphy" is, except where the context otherwise requires, used to cover not only wireless telegraphy and telephony, but also ordinary telegraphy and telephony. The details of the scheme, including estimates of the probable expenditure, have been formulated by a subcommittee¹ whom we appointed for the purpose.

SCHEME.

15. The Government should appoint a national committee for telegraphic research, whose duty it was to promote generally in the public interest, both by theoretical investigation and by experiment, the progress of scientific telegraphy and telephony, and to coordinate and supplement the work now being done in the Government departments interested in such progress.

16. The Government should establish a national research laboratory with a special scientific staff to undertake, under the direction of the committee and on the lines laid down in this report, telegraphic investigation, the results of which should be available for all departments of the public service, and to cooperate with these departments in dealing with the scientific aspects of practical problems arising out of service conditions. This laboratory should be established at Teddington in cooperation with the National Physical Laboratory, under the conditions hereafter specified.

I. THE NATIONAL TELEGRAPHIC RESEARCH COMMITTEE.

MEMBERSHIP OF THE COMMITTEE.

The National Committee for Telegraphic Research should consist of 12 members, and be constituted as follows:

Two members representing the admiralty.

One member representing the war office.

Two members representing the post office.

Two members appointed directly by the treasury.

Three members appointed by the treasury on the nomination of the Royal Society.

One member appointed by the treasury on the nomination of the Institution of Electrical Engineers.

The director of the National Physical Laboratory.

The two members appointed directly by the treasury should not be department officials, the departments being sufficiently represented on the committee in other ways.

The committee should appoint a secretary, and should also out of its own members select a president and a chairman.

The secretary, in addition to possessing the usual qualifications for such a post, including a knowledge of French and German, should be a man of technical training and experience.

¹ This subcommittee consisted of Sir Henry Norman (chairman), Sir Joseph Larmor, Dr. Glazebrook, Mr. Duddell, Rear Admiral Charlton, and Commander Loring.

The appointment of each of the members nominated by the treasury, the Royal Society, and the Institution of Electrical Engineers should be for three years, two of the six retiring in each year. A retiring member should be eligible for reappointment in cases where it is important that his services should be retained.

Of the six members nominated by the treasury, the Royal Society, and the Institution of Electrical Engineers, two should in the first instance hold office for one year, two for two years, and two for three years. All subsequent appointments should be for three years.

Any vacancy should be filled on the nomination of the body which nominated the member whose vacancy has to be filled up.

No member of the committee should give advice connected with telegraphy or telephony to any commercial firm on any matter connected with the work of the committee, except with the consent of the committee, and in any doubtful case such consent should not be given without the approval of the department concerned.

Any member of the committee who may act as adviser to any private firm or individual on any subject dealt with by the committee or investigated in the research laboratory should notify the fact to the president of the committee, and, if the president thinks fit, acquaint him with the nature of the advice he has given or may give him from time to time. In any matter of importance which may be brought before the committee it should be the duty of the president to call the attention of the committee to the fact that one of their number is interested in his private capacity, and thereupon the committee should have power, if it consider it desirable, to request the member in question to withdraw while such matter is being discussed.

DUTIES OF THE COMMITTEE.

The committee should meet at regular intervals. It should be their duty—

(1) To consider generally and to promote by original investigation the progress of telegraphic research, to formulate schemes of investigation at the research laboratory or elsewhere, to supervise the consequent experiments and to discuss the results.

(2) To consider problems submitted by the departments and to arrange for experiments for their elucidation.

(3) To examine plans and designs for new methods and apparatus when submitted to them, and to report thereon if they see fit.

The Government departments would continue to conduct, as now, researches or inquiries arising out of their own administration independently of the work of the committee, and ampler provision for this purpose should be made in the departmental estimates. Where the results of these inquiries are of general interest they should, as far as possible, be communicated to the committee for the advantage of other departments interested.

The departments concerned with telegraphic problems should, on the one hand, be entitled to the assistance of the committee, and should, on the other hand, assist the committee as far as possible in carrying out such researches as can most conveniently be made in

their respective stations; but the head of each department should have absolute discretion in deciding whether any scheme of experiment can be conveniently carried out at a station in his charge.

These departmental stations would include—

- (a) The admiralty wireless stations and experimental depots.
- (b) The post office laboratory and wireless stations.
- (c) The Army experimental section and such field stations as may be available.

With regard to these stations and the work done at them, the committee would be in a purely advisory relation to the departments.

The committee should issue an annual report to be laid before Parliament. They should publish or authorize publication of such researches as they may consider useful for the advancement of science generally, and which are not of a confidential nature.

The committee should have power in its discretion to organize or cooperate in international scientific investigations bearing on telegraphy.

II. THE NATIONAL RESEARCH LABORATORY.

ITS DUTIES AND EQUIPMENT.

The Research Laboratory should be established with a special staff to carry on, under the direction of the National Committee for Telegraphic Research, scientific investigations in the methods of telegraphy, which have relation to the improvement of radiotelegraphic communication within the Empire or are otherwise useful in the public interest, and to assist the departments in dealing with the scientific aspects of practical problems arising out of service conditions.

This laboratory should be established at the National Physical Laboratory at Teddington, under the conditions hereafter specified.

A suitable site for a mast with a small building attached exists in the paddock to the east of Bushy House, and at the proper time H. M. office of works should be approached with a view to obtaining permission for its use.

Arrangements should be made for erecting and equipping at the laboratory the necessary new buildings and plant. The details of this work must, of course, be left for determination by the national research committee when constituted, and will depend largely on the particular scheme of research which such committee may adopt.

The work of the National Research Laboratory should, however, be limited to research and experimental investigations. Routine testing and certifying should continue to be, as it now is, part of the normal work of the National Physical Laboratory, for which the customary fees would be paid to the executive committee of that institution. In cases of doubt as to whether work should properly be undertaken by the Research Laboratory or not, the national committee should decide.

ITS STAFF.

The national research committee should nominate the members of the staff, and these, when approved by the executive committee of the National Physical Laboratory, would be appointed by the latter

as members of the staff of the National Physical Laboratory, and would be subject in all respects to its rules. They would be paid by the executive committee of the laboratory out of funds placed at its disposal for the purpose by the national committee. They would work under the direction of the director, who would receive his instructions—as far as their work is concerned—from the national committee.

There should be free interchange of assistance and information between the research laboratory staff and the departmental staffs with regard to any experimental work undertaken at the laboratory in which the departmental staff is concerned. If thought desirable by the departments and the national committee, arrangements should be made for the members of the departmental staffs to work at the laboratory.

17. Besides formulating the foregoing scheme, we have thought it desirable to estimate as far as we are able the expenditure which will be required in order to carry it into effect. For this purpose we have assumed that the expenditure necessary for research and experimental work undertaken by the departments on their own initiative will be provided for, as is now the case, in the departmental estimates, but that the funds required for the work of the national research committee and the National Research Laboratory will be provided by the Treasury in the form of a grant in aid.

18. The probable expenditure for this work may be considered under the headings of probable annual expenditure and probable capital expenditure.

19. The probable annual expenditure will include (*a*) the honoraria, traveling, secretarial, and other current expenses of the national committee; (*b*) the salaries of the staff and the current expenses of the laboratory; and (*c*) the cost of experimental or research work initiated by the committee at the departmental stations or elsewhere than in the laboratory. The expenditure under (*b*) and (*c*) must depend largely on the particular schemes of work from time to time recommended or adopted by the national committee. With regard to (*a*) we consider that the honoraria of members of the committee may reasonably be fixed at 10 guineas a meeting of the full committee or of a subcommittee appointed by it, the number of paid meetings per member per year not to exceed for the first two years 15, and after the first two years 10 meetings. Such honoraria would not be payable to the departmental members, and in the case of the director of the National Physical Laboratory should be paid to the treasurer of such laboratory.

20. The probable annual expenditure under all three heads has been carefully considered by the subcommittee and on the footing that the honoraria of the members of the committee will be as above indicated and that all printing for the committee will be done by the stationery office, they estimate such expenditure approximately as follows:

Staff of laboratory:

1 principal assistant, commencing at.....	£400
2 assistants, commencing at £200.....	400
5 juniors, commencing at £150.....	750
1 instrument maker.....	125
1 assistant instrument maker.....	100
2 laboratory boys, at £50.....	100
1 porter.....	80
Secretary and clerk.....	300
	<hr/>
	2, 255
Honoraria of national committee.....	1, 100
Expenses of laboratory.....	500
Traveling expenses.....	200
Heating, gas, lighting, insurance, etc.....	245
Cost of work assigned by the national committee to the departments.....	500
	<hr/>
Total annual cost.....	4, 800

21. The above estimate makes provision among the junior staff for a man who, without high scientific qualifications, has had experience in the erection of wireless stations and in the designing, use, and testing of wireless plant, and also for a skilled operator, preferably an ex-Navy man, who would be necessary for the transmission and reception of wireless signals and for carrying out research communications with other stations. The estimate is also made on the assumption that much of the apparatus would be designed and made at the laboratory.

22. With regard to capital expenditure, this may also be considered under three heads: (a) Mast, aerial, and earth connection; (b) buildings; and (c) equipment. Expenditure under all these heads will, of course, be a matter for the consideration of the national committee, but we think it may be assumed that the national committee will require—

1. (a) The erection of a single wooden mast, 150 feet high, with suitable antenna and earth connections.

(b) A one-story building near the foot of the mast, divided into three parts, one to contain the power plant, one the transmitting, and one the receiving apparatus. One room in this building would need to be metallically screened, to permit of the use of certain types of delicate apparatus.

(2) A laboratory building, with a total floor space of 4,000 square feet.

(c) Equipment on a scale suitable to the above.

On this assumption our subcommittee has estimated the capital expenditure required at the outset as follows:

(a) The mast, etc.....	£300
(b) 1. The building at foot of mast.....	1, 000
2. The laboratory building.....	3, 000
(c) Equipment.....	3, 000
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Total.....	7, 300

23. The above estimates have, after full consideration, been approved and adopted by all of us with this exception, namely, that Sir Alexander King and Mr. R. Wilkins consider that they are on a somewhat too liberal scale.

24. We have spoken of expenditure which will be necessary at the outset only. If, as is hoped, the work of the national committee and

the National Research Laboratory is found to be of great value, it is not improbable that the national committee may recommend further expenditure, both capital and annual, and to meet this contingency the buildings above referred to should be so designed as to be readily capable of enlargement. Even if the capital expenditure were increased by £3,000, and the annual expenditure by £2,000, the total cost, including departmental expenditure for the same purposes, would be less than the amount expended for similar purposes by the respective Governments of the United States and Germany.

25. We have also carefully considered the question of the form in which provision could be most appropriately made for the necessary expenditure. On this subject there is a difference of opinion between Sir Alexander King, Mr. R. Wilkins, and Maj. Guest on the one hand and the other members of your committee on the other hand.

26. Sir Alexander King, Mr. R. Wilkins, and Maj. Guest are of opinion that this expenditure should be met, at any rate in the first instance, by a lump-sum grant (payable by annual installments) to cover a definite period, say, five to seven years, leaving the national committee to consider and determine how the amount granted should from time to time be expended. In their opinion the national committee will have no direct incentive to economy nor any responsible head with whom the treasury can discuss proposed expenditure, and they consider that these objections can only be met by a fixed annual grant.

27. The other members of your committee take a contrary view. In their opinion the proposed national committee should not be placed in the position of having to recommend and undertake such work only as can be met out of a fixed annual grant. It will be their business to consider and advise year by year what work in the way of research or experiment ought to be undertaken in the interests of national efficiency, and to estimate the probable cost of such work. The cost of work immediately and urgently required in the public interest might be in excess of the fixed annual grant, and if such work had to be postponed or abandoned for this reason, the usefulness of the national committee might be seriously curtailed. It must be remembered that all the departments interested in telegraphy will be represented on the national committee, and it is almost inconceivable that the national committee could recommend and estimate for work of which the departments, through those representatives, did not approve. The treasury could readily obtain full information as to all such work and the estimates in reference thereto, either from the national committee itself or the departments represented on such committee. In the opinion, therefore, of all the members of your committee (with the aforesaid exceptions), by far the better plan would be for the national committee to prepare year by year a scheme of work which they consider to be desirable, and to forward such scheme to the treasury, with estimates of the funds required for the ensuing year. The treasury would consider these estimates, and if they were approved make provision accordingly. This is the plan which your committee (with the exceptions aforesaid) recommend. It has (as we are informed) been adopted in the case of the aeronautics committee, and has very materially contributed to its success.

28. We understand that in the case of the aeronautics committee the grant in aid is paid into the National Physical Laboratory's

account at the Bank of England, that all payments are made from such account by the treasurer of the laboratory, and that the director of such laboratory is responsible for the accounts. We recommend that, subject to the approval of the treasury, the same plan be adopted in the case of the national committee for telegraphic research.

29. Inasmuch as some time must elapse between the appointment of the national committee and the completion of the building and equipment of the research laboratory under their direction, we have thought it desirable to consider whether some work on the lines we have suggested could not be usefully undertaken in the interval.

30. Among the subjects for investigation specified in the schedule to this report there are certain matters which require immediate attention. We may instance the following:

(1) Researches into the methods of measuring and standardizing electrical quantities under high-frequency conditions. Among those would be included measurements of voltage, current, power, resistance, inductance, capacity, wave length, and decrement.

(2) Investigations into the methods of standardization and construction of instruments, such as condensers, inductances, resistances, wave meters, etc., and the determination of the losses in such instruments.

(3) A study of receiving circuits in general, including variations in type of inductances, condensers, detectors, telephones, relays, and amplifiers.

31. The plant necessary for investigation into these matters would not, at first at any rate, be very extensive, and could, as we are informed by the director of the National Physical Laboratory, be temporarily accommodated in the existing rooms of that institution.

32. We consider it possible that the national committee may desire the opportunity thus afforded of commencing work before the new buildings are completed and equipped.

33. In order to commence work, however, it will be necessary that the national committee should from the date of its appointment have the necessary funds at its disposal, and we have ascertained from the treasury that there will be no difficulty in providing any funds that may be granted by means of a supplementary estimate in June or July of this year. We have carefully considered the amount which is likely to be required by the national committee between their appointment and the end of the current financial year, assuming that the funds required for the subsequent financial years will be provided in the estimates for those years, respectively. In our opinion, in order to allow this interim work to be begun with the least possible delay, and to secure that the necessary buildings and plant be erected and put in working order by as early a date as possible, it will be advisable that the national committee should at once have at its disposal a sum of £4,000, of which £1,000 would be for the current expenses of the committee, £1,500 for the staff and current expenses of the interim work in the National Physical Laboratory, £500 for the purchase of plant for the purpose of such interim work, and £1,000 toward the cost of the mast and aerial and the buildings connected therewith, which ought to be put in hand at once.

34. The consent of the Committee of the National Physical Laboratory will have, of course, to be obtained before the scheme we recommend can become operative, and if this scheme is accepted by the

Government it would be well to approach such committee for the purpose of obtaining such consent. Subject to questions of detail we have satisfied ourselves that the scheme will be welcomed by the National Physical Laboratory.

35. We desire to add that the scheme and provisional estimates hereinbefore set forth have been submitted to and considered and approved by Lord Rayleigh, Sir Oliver Lodge, and Dr. Schuster, the secretary of the royal society, and we have to thank all these for the valuable assistance they have given us.

36. We also desire to thank Col. Squier, United States military attaché in London; Dr. Lewald, of the ministry of the interior, Berlin; and Dr. Strecker of the Kaiserliches Versuchsammt, Berlin, for supplying us with information as to the research work in wireless telegraphy undertaken by the Governments of the United States and Germany, respectively. We have also to thank our secretary for his services to the committee.

PARKER OF WADDINGTON.

JOSEPH LARMOR.

HENRY NORMAN.

R. T. GLAZE BROOK.

W. DUDELL.

ROLAND WILKINS.

JOHN K. IMTHURN.

A. F. KING.

W. SLINGO.

F. LORING.

HENRY C. GUEST.

JOHN S. FOWLER.

EDWARD F. CHARLTON.

S. J. FARRER, *Secretary*.

SCHEDULE.

Improvements in methods of measurement of fundamental electrical quantities under high-frequency conditions.

Transmitting condensers.—Measurement of efficiency of dielectrics used at different voltages, frequencies, and temperatures; quantitative results by which losses can be predetermined.

Insulating materials.—Behavior at high frequencies and voltages, and best methods of use.

Receiving condensers.—Efficiency of different types.

Transmitting and receiving inductances.—Study of details of design with a view of minimizing energy loss.

Receiving devices.—Investigation of crystal and valve detectors under different conditions, and best methods of modifying these to obtain desired characteristics. Effect of variation of coupling between detector circuit and the rest of the receiving circuit. Effect of variation of inductance and capacity in receiving circuit. Methods of mounting and preparing crystals. Methods of amplification of received signals, both acoustic and electrical.

Aerial wires and earth connections.—Measurements of losses due to brushing from different types of aerials at high frequencies. Measurement of decrement of aerial and earth system. Conductivity of different kinds of soil at high frequencies. Measurement of losses in steel-plate earth connections. Measurements on model aerials to assist in design and to predetermine losses. Investigation of "earth antennæ."

New systems and apparatus.—Investigation of new systems of wireless telegraphy and apparatus employed therein, which may be submitted to the committee and deemed by the committee worthy of investigation.